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ISENTROPIC COMPRESSION DATA ON LX-04 EXPLOSIVE AT 150°C USING THE Z ACCELERATOR

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Abstract. Isentropic compression data was collected on LX-04 explosive (85% HMX and 15% Viton by weight) at 150°C using the Sandia National Laboratories Z accelerator facility. A ramp compression wave was applied to the explosive samples mounted on aluminum panels with VISAR interferometry measuring the sample and backing window interface velocity. Heating was obtained by wrapping band heaters around a thermal mass attached to each panel and temperatures were recorded by thermocouples at several locations on the panel. This work will outline the methods used, discuss the VISAR interface velocities, and present the preliminary data obtained on heated LX-04. These results demonstrate the ability to perform experiments on preheated samples to obtain isentrope data.

INTRODUCTION

The Z accelerator facility at Sandia National Laboratories (SNL) offers a viable tool for performing "Isentropic Compression Experiments" (ICE) [1-3]. This is accomplished by using a large-amplitude, short-duration current pulse delivered into a metal panel "floor" which backs the sample and creates a ramp compression wave from the magnetic pressure.

The ICE technique has been useful in studying the isentrope (and associated Hugoniot) of high explosives (HE). LX-04, an HMX based explosive, with 85% HMX and 15% Viton [4] has been studied in previous ICE experiments [5-7]. Prior works have also investigated the heated shock response and equation of state LX-04 [8-9]. In this work, a pre-heating technique was utilized to heat ICE samples and load them to investigate the technique and hopefully obtain usable data. The procedure utilized and results obtained will be discussed with suggestions for future work and improvements on subsequent experiments.

PROCEDURE

LX-04 samples (85% HMX, 15% Viton-A) with thickness of 200-700 μm and 6 mm diameter were mounted onto 6061 aluminum

panel assemblies. Figure 1 shows a photograph of the West panel showing the 3 measurement locations on the right and cavity location on the left for placement of the copper thermal mass that gets surrounded by a band heater. A block can be seen above the sample locations, which is covering the sample thermocouple locations. Thermocouples were also placed on the thermal mass near the band heaters.

Each panel contained 2 LX-04 samples backed by 6 mm diameter by 3 mm thick NaCl (100) windows. The aluminum floor thickness below each sample was approximately 1 mm. Table I contains the sample thickness and window information on each panel. The NaCl windows were used because they have a good acoustic impedance match to the LX-04 and the experiment pressure was expected below the NaCl 25 GPa phase transition. VISAR laser interferometry [10] was used to measure the window interface and panel free surface velocities.

All 4 of the panels similar to that pictured in Figure 1 were assembled in a "square short" arrangement with each panel making up a side of the square. Note that in Figure 1, the panel is laying sideways with the top being toward the right and the bottom at the left. This created an anode insert opening of 26 mm x 26 mm which was placed around a 20 mm by 20 mm cathode stalk to create a 3 mm gap all the way around. After assembly of the target was complete, the four panels were preheated to approximately 150°C and the Z machine was fired.

TABLE I. Summary of sample thickness measurements and window information on panels with LX-04

DETAIL	NORTH PANEL	SOUTH PANEL	WEST PANEL
Top sample t	192 μm	399 μm	602 μm
Top window	NaCl	NaCl	NaCl
Middle (no sample)	NaCl	NaCl	NaCl
Bottom sample t	293 μm	504 μm	708 μm
Bottom Window	NaCl	NaCl	NaCl

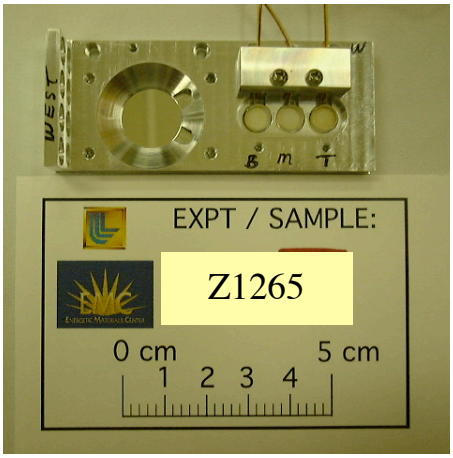

FIGURE 1. Photograph of samples and windows mounted on the West panel for experiment Z1265.

RESULTS/DISCUSSION

The results for the experiment include the heating temperature profile, current profile from the machine, and velocity histories of the drive measurements and panels. Figure 2 displays the thermocouple readings from the South panel. All panels showed a similar heating profile with a temperature variation of approximately 2-5°C from panel to panel. Note that there was a slight temperature overshoot from the desired 150°C and the heaters were turned off prior to firing as shown by the peak followed by a dip at the end of the temperature record.

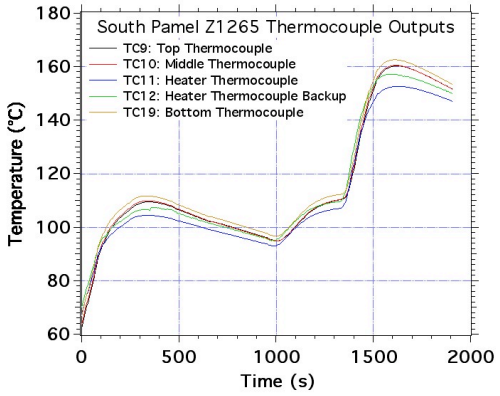

FIGURE 2. Temperature profile of the South panel.

The current pulse (average of 4 probes) achieved during the experiment is shown in Figure 3 and shows about a 15 MA peak pulse and a 400 ns duration pulse ramp rise time.

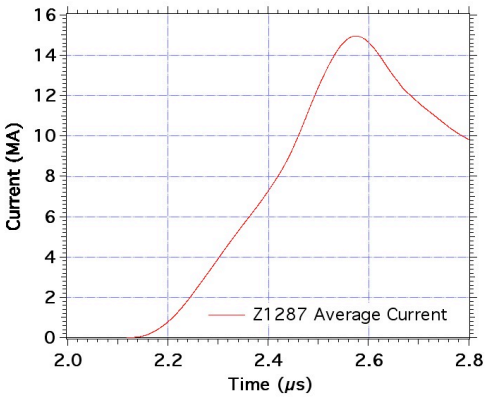

FIGURE 3. Current measurement for Z1287.

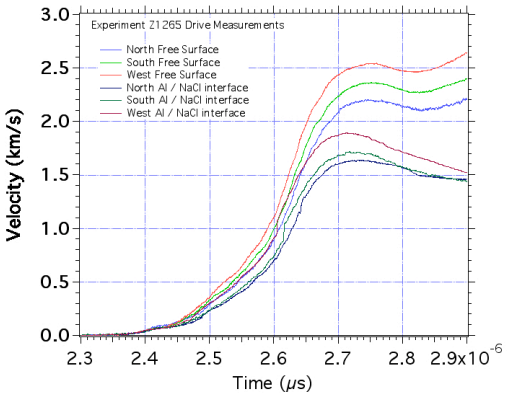

FIGURE 4. Drive measurements for Z1265 panels with LX-04 samples.

Figure 4 shows the drive measurement for all three panels with LX-04 samples. Note that the aluminum free surface velocity measurements show a higher velocity than the profiles for the Al/NaCl interface velocity due to the presence of the NaCl window. It can be noticed that the velocities are not consistent from panel to panel, but the relative ratios of free surface to Al/NaCl interface velocities on each panel correlate together. This appears to show that possibly the drive was not symmetric, possibly due to slight expansion changes during the heating of the target assembly.

Figures 5, 6 and 7 show the VISAR traces for the North, South, and West panels with LX-04 samples respectively. As shown in Figure 4, the drive measurements on each panel are included in these plots. The North and South panels did yield a somewhat usable velocity profile for the thin samples, but the West panel did not. Note that in all cases, the thicker sample did not show a quality velocity trace. This may be due to loss of reflectively from the sample/window interface or the sample severely shocking up during the experiment resulting in several missed VISAR fringes.

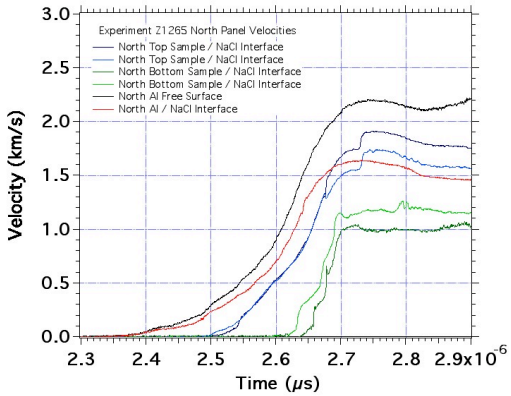

FIGURE 5. VISAR traces of North panel samples.

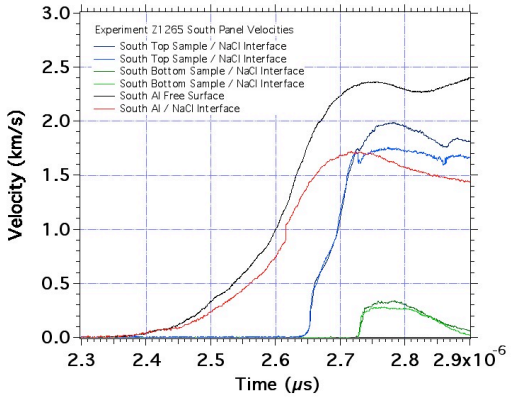

FIGURE 6. VISAR traces of South panel samples.

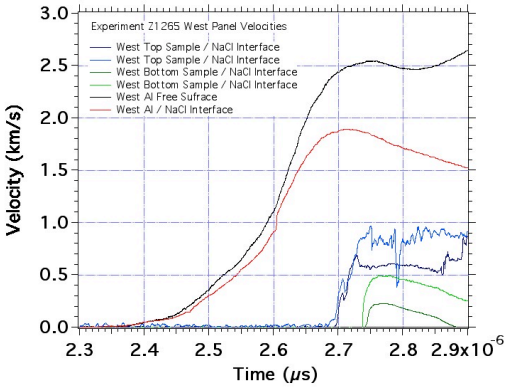

FIGURE 7. VISAR traces of West panel samples.

It may be possible to obtain isentrope data from the thin samples on the North and South panels, but the associated errors may be high due to the limited data.

SUMMARY AND FUTURE WORK

An experiment using LX-04 samples pre-heated to approximately 150°C was performed on the Z accelerator at Sandia National Labs. This research demonstrates the ability to collect isentrope data on pre-heated samples. Window reflectivity at elevated temperature proved to be a problem for several of the window interfaces.

Future work is planned to perform further analysis on the data to investigate the possible calculation of an isentrope. It is unsure at this time whether an additional window and sample corrections will be needed due to the pre-heated nature of the experiment. Improvements to the pre-heating experiments including resolving any window reflectivity issues are in progress and future experiments are planned.

ACKNOWLEDGEMENTS

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